

REMARKS

This paper is being presented in response to the non-final official action dated February 9, 2006, wherein:

- (a) claims 11-30 were pending;
- (b) claim 26 was rejected under 35 USC § 102(b) as anticipated by Angelucci et al. "Permeated Porous Silicon for Hydrocarbon Sensor Fabrication" ("Angelucci");
- (c) claims 11, 12, and 26 were rejected under 35 USC § 102(b) as anticipated by Lammel et al. "Free-Standing, Mobile 3D Porous Silicon Microstructures" ("Lammel");
- (d) claims 11-13 were rejected under 35 USC § 102(b) as anticipated by Tjerkstra et al. "Multi-Walled Microchannels: Free Standing Porous Silicon Membranes for Use in μ TAS" ("Tjerkstra");
- (e) claims 14, 15, and 27-29 were rejected under § 103(a) as obvious over Kaltsas et al. "Novel C-MOS Compatible Monolithic Silicon Gas Flow Sensor with Porous Silicon Thermal Isolation" ("Kaltsas") in view of Lammel;
- (f) claims 16-21 were rejected under § 103(a) as obvious over Kaltsas in view of Lammel, and further in view of Sabaté et al. "Evaluation of Sensitive Materials for Integrated Thermal Flow Sensors" ("Sabaté");
- (g) claims 22, 25, and 30 were rejected under § 103(a) as obvious over Kaltsas in view of Lammel, and further in view of Hedrich et al. "Structuring of Membrane Sensors Using Sacrificial Porous Silicon" ("Hedrich");
- (h) claims 23 and 24 were rejected under § 103(a) as obvious over Kaltsas Lammel, and Hedrich, and further in view of Sabaté; and,
- (i) claims 14 and 27-30 were objected to as "awkward" (claim 14) and as lacking antecedent basis (claims 27-30).

This paper is timely filed as it is accompanied by a petition under 37 CFR § 1.136(a) for an extension of time to file in the sixth month, and the required extension fee.

I. Brief Summary of the Amendments

A. Amendments to the Claims

Claims 11-30 have been canceled.

New claims 31-40 have been added, with a total of three independent claims (31, 39, and 40). Support for the claims is found, for example, in the following locations:

Claim 31: Paragraphs [0006], [0007], and [0028];

Claim 32: Paragraphs [0007] and [0029];

Claim 33: Paragraph [0012];

Claim 34: Paragraph [0013];

Claim 35: Paragraphs [0007] and [0029];

Claim 36: Paragraph [0012];

Claim 37: Paragraph [0013];

Claim 38: Paragraphs [0010] and [0030];

Claim 39: Paragraphs [0006], [0028], [0029], and [0031]; Figure 2; and,

Claim 40: Paragraphs [0006], [0028], [0030], and [0032]; Figure 6.

By these amendments, the rejections of claims 11-30 and the objections to claims 14 and 27-30 are rendered moot.

No new matter has been introduced by the foregoing amendments.

B. Amendments to the Specification

Paragraph [0007] of the specification has been amended to correct a typographical error by replacing “n-type poly/Al” with “p-type poly/Al” as a thermocouple material. Support for this amendment is found, for example, in paragraph [0031] (Example 4) which describes the thermocouples of a thermal flow sensor as “consisting of p-type polycrystalline silicon (8) and aluminum (9) metal lines or p-type/n-type polycrystalline silicon lines.” Amendments to the specification that are supported in the original description are not new matter. See MPEP § 2163.07.

No new matter has been introduced by the foregoing amendment.

II. None of the Present Claims Are Anticipated Under 35 USC § 102(b)

Angelucci, Lammel, and Tjerkstra were independently cited as anticipatory references in the official action. See p. 3-5 of the action. “A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single

prior art reference.” *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631 (Fed. Cir. 1987). It is respectfully submitted that none of new claims 31-40 is anticipated by Angelucci, Lammel, or Tjerkstra.

A. Angelucci Does Not Anticipate Any Pending Claim

Angelucci is directed to a hydrocarbon sensor and the use of a porous silicon membrane in the sensor. The porous silicon membrane and open area beneath it are formed by first etching the silicon from the back side of the substrate with KOH and then forming the porous silicon membrane with an electrochemical cell. Angelucci, p. 96, col. 1. Thus, Angelucci does not disclose “forming a sealed microchannel” as recited in steps (d)(i) and (d)(ii) of claim 31. Further, Angelucci discloses neither an ohmic contact anode (recited in claims 31 and 39) nor any structure related to inlet/outlet regions of a microchannel (claim 40). See Angelucci, p. 96, cols. 1-2 (“Experimental” section describing method of forming the sensor structure) and Figure 1 (showing the sensor microstructure).

B. Lammel Does Not Anticipate Any Pending Claim

Lammel is directed to microstructures containing porous silicon. Lammel discloses the formation of porous silicon followed by electropolishing to form a porous silicon layer above an electropolishing gap. See Lammel, p. 356 (abstract) and p. 358, col. 1 (Figure 4). However, Lammel does not disclose a masking layer comprising a bilayer of silicon dioxide and polycrystalline silicon on the top side of the silicon substrate as recited in claim 31. See Lammel, p. 357, col. 1 (disclosing masking materials such as photoresists and metal masks, typically including a chromium adhesion layer, as well as a silicon nitride mask). Further, Lammel discloses no structure related to thermal flow sensors or thermal microfluidic sensors as recited in claims 39 and 40. See Lammel, p. 359, col. 1 to p. 360, col. 1 and Figure 6 (describing the use of free-standing, mobile plates of porous silicon in microactuators).

C. Tjerkstra Does Not Anticipate Any Pending Claim

Tjerkstra is directed to multi-walled microchannels using porous silicon membranes. Tjerkstra does not disclose a masking layer comprising a bilayer of silicon dioxide and polycrystalline silicon on the top side of the silicon substrate as recited in claim 31. See Tjerkstra, p. 496, col. 2 (disclosing the use of silicon nitride as the masking material deposited on a silicon wafer). Further, Tjerkstra discloses no structure related to thermal flow sensors or thermal microfluidic sensors as recited in claims 39 and 40. See Tjerkstra, p. 495 (abstract) and p. 500, cols. 1-2 (describing potential applications of the multi-walled microchannels in microsieves, microbatteries, and porous electrodes).

III. None of the Present Claims Are Obvious Under 35 USC § 103(a)

Kaltsas, Lammel, Sabaté, and Hedrich were cited in the official action as prior art references rendering certain claims obvious. See p. 5-19 of the action. Each of the obviousness rejections involves the combination of at least Kaltsas and Lammel. Kaltsas is cited for its disclosure of a porous silicon layer and thermal sensor-related structure on the silicon substrate. See, e.g., p. 6-7 of the action. Lammel is cited for the disclosure of porous silicon membranes with cavities beneath them formed by electrochemical dissolution, which disclosure is lacking in Kaltsas. See, e.g., p. 7-8 of the action. Sabaté and Hedrich are cited for specific claim features, for example a passivation layer (Sabaté; see p. 11 and 19) and the inlet/outlet structure of a microfluidic channel (Hedrich; see p. 14-15).

It is respectfully submitted that none of new claims 31-40 is obvious in view of any combination of Kaltsas and Lammel that optionally includes Sabaté, Hedrich, or both.

A. Proper Basis for a § 103(a) Rejection

To establish a *prima facie* case of obviousness, the PTO must satisfy three basic criteria. First, the combined disclosure of the prior art references must teach or suggest all of the claim limitations. Second, there must be some suggestion or motivation to modify or combine the teachings in the art to make the precise combination recited in the claims. A prior art reference must be considered in its entirety, including portions that would lead away from the claimed invention, and it is improper to combine references where the references teach away from their combination. Finally, a person having ordinary skill in the art must have a reasonable expectation of success when combining or modifying the disclosures of the references. The suggestion or motivation to make the claimed invention and the reasonable expectation of success must both be derived from the prior art, and not from the application's disclosure. See MPEP §§ 2141-43 and § 2145 (8th ed., October 2005).

Objective evidence of unexpected results is relevant to the issue of obviousness and must be considered when it is present. Superiority of a property shared with the prior art is evidence of nonobviousness as an unexpected result. See MPEP § 716.02(a) and § 2141.

B. No Prima Facie Case of Obviousness Exists Based on the Combination of Kaltsas and Lammel

1. There is No Motivation to Combine Kaltsas and Lammel

Kaltsas is directed to a C-MOS compatible silicon gas flow sensor using porous silicon as a thermal insulator. Kaltsas does not disclose a "microchannel [formed] below the porous silicon capping layer" (claim 31) or a "porous silicon capping layer . . . locally formed above the microchannel" (claims 39 and 40). See Kaltsas, p. 134, col. 1 to p. 135, col. 1 and Figure 2 (failing to mention or show any channel or cavity under the porous silicon layer "A" of the silicon wafer).

Lammel is discussed in Section II.B above.

Kaltsas discusses the following alternative to its disclosure of a single porous silicon layer as a thermal insulator:

An alternative is to use bulk silicon micromachining in order to produce cavities, which offer the adequate thermal isolation [1, 2]. This type of sensors is usually based on the use of microbridges, which make them fragile. In addition, they don't allow much design freedom and they demand double side lithography and long etching times.

Kaltsas, p. 133, col. 2. The official action refers to this passage in support of the combination Kaltsas with the method of Lammel to create a cavity underneath a porous silicon membrane. See p. 7-8 of the action.

However, the official action ignores the teaching of Kaltsas that such structures are undesirable because of the fragility of the resulting structure and processing limitations such as double side lithography. This impermissibly ignores that portion of the cited references that teach away from their combination. See MPEP § 2141.02.VI and § 2145.X.D.2.

Specifically, there is no suggestion that the combination of Kaltsas and Lammel would eliminate the problem of a fragile microstructure. On the contrary, Lammel teaches the skilled person in multiple instances that its method *does* result in a fragile microstructure. See Lammel, p. 358, col. 1 (noting that "if the generation of gas bubbles during [the] subsurface electropolishing is too violent, the porous [silicon] layer will break"); p. 359, col. 1 (indicating that "drying the structure after the electrochemical etch process is the most delicate step" and that "drying the wafer in a spinner or with a nitrogen gun would damage the structures").

Further, the claimed methods and sensors are able to retain the positive benefit of an insulating microchannel by eliminating the undesirable double side lithography step (i.e., an additional processing step) and by forming the microchannel with a preexisting electropolishing step used to create the porous silicon insulating layer. The omission of an element (i.e., double side lithography step) in a manner that retains the element's function (i.e., the formation of an insulating microchannel) is an indicium of unobviousness. See MPEP § 2144.04.II.B.

2. The Applicants Have Demonstrated Unexpected Results for the Claimed Invention

Even if Kaltsas and Lammel are combined, the methods and devices recited in the claims are unobvious based on the existence of unexpected results.

Figure 5 of the specification illustrates that the thermal isolation provided by a porous silicon capping layer above a microchannel (i.e., as recited in claims 31, 39, and 40) increases the sensitivity of the claimed device as compared to a porous silicon layer in contact with a silicon substrate (i.e., as disclosed by Kaltsas). See ¶ [0009] of the

specification. Figure 5 compares the temperature increase on the structure for a device having a 20 μm -thick porous silicon membrane above a 20 μm -thick microchannel with the temperature increase for a prior art device having a 40 μm -thick porous silicon membrane. See ¶ [0009] of the specification. Figure 5 shows a peak temperature increase for the claimed invention that is more than three times greater than that of the prior art at the heater location (i.e., about 330 K compared to about 100 K). Further, Figure 5 shows non-negligible temperature increases for the claimed invention that spatially extend about twice as far as the prior art (i.e., about 200 μm compared to about 100 μm).

This increase in sensitivity is not an expected property, because a 20 μm insulating microchannel was not simply added to the 40 μm porous silicon membrane of Kaltsas (in which case an additive insulating effect might be expected). Instead, the comparison shows the unexpected benefit of combining the porous silicon and microchannel insulators while maintaining the same insulation thickness of Kaltsas (i.e., 40 μm ; see Kaltsas, p. 133, col. 1). This superior sensitivity is evidence of nonobviousness sufficient to overcome even a proper prima facie obviousness rejection. See MPEP § 716.02(a).

C. Neither Sabaté nor Hedrich Remedy the Deficiencies of the Combination of Kaltsas and Lammel

Neither Sabaté nor Hedrich (alone or in combination) remedy the deficiencies in the base combination of Kaltsas and Lammel, as explained above.

Sabaté is directed to calorimetric flow sensors and is cited by the action for its disclosure of passivation layers as presently recited in independent claims 9 and 10. Sabaté discloses platinum, nickel, and polysilicon as sensing materials deposited over a thin dielectric membrane. See Sabaté, p. 2681 (abstract). The dielectric membrane is a silicon nitride layer and the silicon substrate is a double side polished wafer. See Sabaté, p. 2682, col. 2. Because Sabaté is not concerned with porous silicon and/or electropolishing, it does not remedy the deficiencies of Kaltsas and Lammel.

Hedrich is directed to thermal transducers and is cited by the action for its disclosure of an inlet/outlet in a channel. Hedrich discloses the use of sacrificial porous silicon to create a gap between a transducer membrane and a silicon substrate. See Hedrich, p. 315 (abstract). A silicon nitride layer serves as the transducer membrane, and the porous silicon is completely etched from the resulting structure. See Hedrich, p. 317, col. 2. Because Hedrich does not disclose a remaining porous silicon layer in the final structure and/or electropolishing to create a channel, it does not remedy the deficiencies of Kaltsas and Lammel.

CONCLUSION

In view of the foregoing, entry of new claims 31-40 and allowance of all pending claims 31-40 are respectfully requested.

Should the examiner wish to discuss the foregoing, or any matter of form or procedure in an effort to advance this application to allowance, the examiner is urged to contact the undersigned attorney.

Respectfully submitted,

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